

## MEMORANDUM

Date: Thursday, October 4, 2007

To: Project Stakeholders

From: Kris Beatty, King County Solid Waste Division, LinkUp program manager on behalf of the LinkUp Shingles in Paving Demonstration Project Team

Subject: Recycled Asphalt Shingles in Hot Mix Asphalt Research: Summary of Relevant Projects

### **Background**

The project team committed to providing a written summary of shingles recycling research as one of the outcomes of the August 21, 2007 *King County LinkUp Shingles in Paving Demonstration Project* stakeholders meeting. This memo outlines key research findings about shingles recycling, summarizes select demonstration projects, and identifies next steps to help further disseminate relevant resources to stakeholders throughout this project.

The *LinkUp Shingles in Paving Demonstration Project* is a continuation of research on opportunities for growth in shingles recycling. King County LinkUp has been conducting research and connecting with experts to identify new opportunities and markets for recycling tear-off asphalt shingles. The objective of the current 2007/2008 project is to champion the development of a hot mix asphalt (HMA) end-market for tear-off shingles by conducting a paving trial in the Puget Sound area that incorporates this material.

King County LinkUp is maintaining a project Web page at: <http://www.metrokc.gov/dnrp/swd/linkup/shingles/index.asp>. This Web page currently includes links to several King County background documents:

- *Waste Monitoring Program Market Assessment of Construction and Demolition Waste Materials*. Final Report (2004). Section 3.3. Asphalt Shingles Current Supply. Prepared by Cascadia Consulting Group, Inc.  
[http://www.metrokc.gov/dnrp/swd/about/documents/C-D\\_Markets\\_report-final.pdf](http://www.metrokc.gov/dnrp/swd/about/documents/C-D_Markets_report-final.pdf)
- *Increasing recycling of tear-off asphalt shingles nationwide* (Spring 2007) in the LinkUp program's quarterly newsletter, *e-Newslink*:  
[http://www.metrokc.gov/dnrp/swd/linkup/documents/eNewslink\\_Spring-2007.pdf](http://www.metrokc.gov/dnrp/swd/linkup/documents/eNewslink_Spring-2007.pdf)

Project Stakeholders will be notified when additional research documents are posted on the Web page. Also, King County LinkUp is maintaining a "LinkUp Blog" at <http://www.metrokc.gov/dnrp/swd/linkup/blog.asp?ID=19&CatID=8> where news and updates on King County LinkUp focus materials, including asphalt shingles, are posted. Users are invited to comment on blog entries.

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**Summary of Shingles Research**

There is a rich and deep history of research and development on the emerging technology of using recycled asphalt shingles (RAS) as a road construction material supplement. The body of published literature extends from the mid 1970's. The literature includes both government research publications and private reports and patent applications. For links to many of the past shingles recycling studies, reports and articles in trade publications, please see the following links:

- [www.ShingleRecycling.org](http://www.ShingleRecycling.org)
- [http://shinglerecycling.org/index.php?option=com\\_content&task=view&id=52&Itemid=76](http://shinglerecycling.org/index.php?option=com_content&task=view&id=52&Itemid=76)

As shown in Table 1, the practice of using manufacturers' RAS in hot mix asphalt (HMA) is now accepted in 15 states, of which 11 have state DOT materials specifications. Tear-off shingles are allowed in three states' DOT specifications. Six states have beneficial use determinations (BUDs) issued by their environmental agencies to allow tear-off shingles in HMA or other specified construction applications. BUDs are a regulatory tool used by state environmental agencies to help guide the approval process for proposed reuse, recycling and recovery projects.

**Table 1. Recycled Asphalt Shingles: State DOT Specs and BUD Approvals**

State	State DOT Specs	RAS Type	State BUD License	RAS Type
<i>Only Manufacturer Scrap Allowed</i>				
DE			<a href="#">BUD for M scrap</a>	M
IN	<a href="#">5% M scrap only</a>	M		
NC	<a href="#">5% M scrap only</a>	M		
NJ	<a href="#">5% M scrap only</a>	M		
PA	<a href="#">Provisional Spec P—c04031A</a>	M		
TX	<a href="#">M scrap only</a>	M		
VA	<a href="#">Special provision</a>	M		
<i>Tear-off Scrap Allowed</i>				
CT			<a href="#">General BUD permit for recycling and storage of tear-off scrap</a>	T
GA	<a href="#">5% M or T scrap</a>	M, T		
MA	5% M scrap	M	<a href="#">MA BUD for M or T scrap</a>	M, T
ME			<a href="#">BUD for T scrap</a>	M, T
MN	<a href="#">5% M scrap only</a>	M	BUD permit by rule for both M and T	M, T
MO	<a href="#">5% M or T scrap</a>	M, T		
NY			<a href="#">BUDs</a>	M, T
SC	<a href="#">3-8% T scrap</a>	T		

**Key to type of shingle scrap allowed:**

*M: Manufacturers' shingle scrap is allowed / recycled*  
*T: Tear-off shingle scrap is allowed / recycled*

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There are at least three dozen road construction projects that have utilized tear-off RAS. Many of these are controlled research efforts, while some are privately-owned and/or not well documented. The [www.shinglerecycling.org](http://www.shinglerecycling.org) Web site is a good resource for learning about the successes and challenges of these projects. In particular, the following links provide information on various states' field studies, as well as key technical reports and papers:

- States' experience:  
[http://www.shinglerecycling.org/index.php?option=com\\_content&task=view&id=136&Itemid=118](http://www.shinglerecycling.org/index.php?option=com_content&task=view&id=136&Itemid=118)
- Technical reports and literature:  
[http://www.shinglerecycling.org/index.php?option=com\\_content&task=view&id=52&Itemid=76](http://www.shinglerecycling.org/index.php?option=com_content&task=view&id=52&Itemid=76)

In the early 1990s, the Georgia Department of Transportation (GDOT) began investigating the possibility of incorporating recycled shingles into road materials. In response to a local shingle manufacturer offering material from their manufacturing process, GDOT conducted testing with this material in 1994 and 1995. The results of the study indicated that incorporating up to 5% RAS resulted in a satisfactory paving application. The study led to a specification for the use of manufacturer scrap in paving applications, and a recommendation that a specification allowing postconsumer (tear-off) shingles be developed. In 2001, a specification that allowed for the use of up to 5% tear-off or manufacturing scrap roofing shingles was approved by the State Transportation Board. Currently, two companies are known to use manufacturing scrap in asphalt paving. Although the state DOT specification allows for the use of tear-off scrap in paving applications, a representative from one shingles recycling company reported that tear-off shingles are not generally used because of access to an ample supply of manufacturing scrap.

Recent projects involving tear-off shingles in Minnesota, Missouri and South Carolina have been selected for a more detailed review in this memo and are presented below. These are the states with active, regular paving projects or research studies using tear-off RAS into HMA for road construction. Table 2 at the end of this memo highlights select projects from these states. These studies were all conducted within the past three years, focus on tear-off shingles, involve both lab and field components, and have corresponding HMA pavement construction projects. In part as a result of their in-depth experiences, both the Missouri and Minnesota Departments of Transportation are part of a three-state task force (also including Kentucky DOT) that is reviewing the current asphalt shingle related specifications of the American Association of State Highway and Transportation Officials (AASHTO) and will soon be making recommendations for improvements.

### **AASHTO**

AASHTO published a new provisional specification and recommended practice for shingle recycling into HMA in July 2006. This culminated a substantial amount of recycled shingles specification development work supported in part by the Recycled Materials Resource Center (RMRC). One objective of the AASHTO provisional specification and practice is to address the needs for quality assurance / quality control (QA/QC) during the processing and utilization of recycled asphalt shingles in HMA. The AASHTO standard and practice provide detailed technical guidance including:

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- Types, definitions, sources, and sampling
- Gradation of RAS
- Addition rates of RAS into HMA
- Deleterious substances
- Methods of sampling and testing

The LinkUp Shingles in Paving Demonstration Project will continue to monitor the development and adoption of ongoing revisions to the AASHTO shingle recycling provisional specification and recommended practice. As indicated above, a three-state DOT task force (MN, MO and KY) is currently preparing a report on their review of the current AASHTO standard and practice. This task force will likely recommend changes to the AASHTO standard and practice that will be presented to the AASHTO committees in the spring of 2008.

### **CMRA**

Several projects by the Construction Materials Recycling Association (CMRA), in collaboration with the U.S. Environmental Protection Agency (U.S. EPA), are currently underway to help develop the market for recycling of asphalt shingles. One of the CMRA projects is near completion and was funded in part by a grant from the U.S. EPA's Office of Solid Waste and Emergency Response (OSWER) Innovations Workgroup. The primary goal of this project is to develop, demonstrate and document best practices that can be utilized by shingle recycling operators.

Dan Krivit and Associates is writing a *Best Practices Guide* as one of three CMRA products. A second report, titled *Environmental Issues Associated with Asphalt Shingle Recycling*, is being written by Innovative Waste Consulting Services, LLC and produced by CMRA. The Web page, [www.ShingleRecycling.org](http://www.ShingleRecycling.org), is an ongoing project of the CMRA and will post these additional shingles recycling publications by November 2007.

### **Minnesota, Missouri and South Carolina Research Projects**

#### **Minnesota**

The Minnesota Department of Transportation (Mn/DOT) has been one of the leaders in the research and development of RAS as a supplement in HMA. The Turgeon (1991), [Newcomb \(1993\)](#), [Newcomb \(2003\)](#), and [Janisch \(1996\)](#) studies are some of the most relevant government lab and field research published on this topic. These laboratory and field investigations, sponsored by Mn/DOT and the Minnesota Office of Environmental Assistance (MOEA), led to the development of a Mn/DOT construction material specification, originally adopted in 1996, for the recycling of manufacturers' shingles scrap into HMA. The Mn/DOT-sponsored field demonstrations using RAS in HMA pavements date back to 1990. Recent informal evaluations have indicated that these earlier shingle-derived pavement test sections were performing at least as well as the control sections without shingles.

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Most recently, Ramsey County in Minnesota initiated a paving demonstration project for a pedestrian/bike trail in Maplewood, Minnesota. The project specifications approved by Mn/DOT called for a 5% mix of tear-off shingles in the HMA and the County received multiple bids for the project. The contractor has been selected, a supply of tear-off shingles has been secured, grinding and screening is scheduled for October 11, 2007, and paving is scheduled for mid October. Results from the research study will be forthcoming.

Mn/DOT has been involved with two additional recent shingles recycling demonstration projects: the *Dakota County / MOEA Lab Study* (2004 – 2006) and the *Hassan / Omann Study* (2006 – 2007). The *Hassan / Omann Project* used both manufacturers' and tear-off recycled asphalt shingles (RAS) at 5% and 10% of the total mix. No recycled asphalt pavement (RAP) was included. The demonstration included RAS in both the wear and base course. All but one of the test mixes used the "standard" virgin asphalt binder performance grade (PG) of PG 58-28. In one of the mixes, the virgin binder asphalt cement (AC) was adjusted to one grade softer to PG 52-34. The pavement test strips were constructed in August 2006 and visual inspections conducted since then indicate no performance differences to-date. The lab results are extensive, although yet unpublished, and include the following selected, tentative conclusions:

- It is difficult to interpret results to the point of firm conclusions because of limited number of samples and complex, multiple variables affecting HMA performance.
- The impacts of adding RAS, including the interactions with virgin aggregate and virgin binder, is still not well understood.
- Low temperature and fatigue cracking is most likely the property that will control the performance of HMA amended with tear-off RAS.
- The relative impacts of tear-off vs. manufacturers' RAS on the PG grade were about the same at the 5% RAS level.
- The high temperature critical performance of the HMA samples increased (i.e., improved) with the increasing amount of RAS in the mix and more so with tear-offs compared to manufacturers' shingles. The low temperature critical performance of the HMA samples increased (i.e., worsened) with the increasing amount of RAS in the mix and more so with tear-offs compared to manufacturers' shingles. The impacts of tear-off RAS on the PG grade at the 10% RAS level was about:
  - High temperature = 2 ½ grades
  - Low temperature = ½ grade
- Adjusting the virgin asphalt binder to the softer, PG 52-34, decreased both the high temperature and low temperature by ½ grade. The resulting final mix, with the adjusted, softer virgin binder, was close to original, targeted mix design PG 58-28.
- The amount of deleterious material (using the AASHTO method) varied considerably from one sample to the next. The material was primarily plastic and paper. The results ranged from about 0.03% to 0.21% with no readily apparent trend.

The following links offer further details on the *Hassan / Omann Project*.

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- **Dan Krivit and Associates** (May 31, 2007) "Recycled Tear-off Shingles Road Construction Demonstration in the Town of Hassan" Final report to the Minnesota Local Road Research Board:  
[http://shinglerecycling.org/images/stories/shingle\\_PDF/final%20lrrb-opera%20report%20hassan-omann%20demonstration%205-31-07.pdf](http://shinglerecycling.org/images/stories/shingle_PDF/final%20lrrb-opera%20report%20hassan-omann%20demonstration%205-31-07.pdf)
- **McGraw**, Jim, Mn/DOT (July 11, 2007) Power Point presentation at the *Hassan / Omann Project* luncheon meeting.  
[http://shinglerecycling.org/images/stories/shingle\\_PDF/hassan%20twp%20shingle%20study%20jm%2007.07.pdf](http://shinglerecycling.org/images/stories/shingle_PDF/hassan%20twp%20shingle%20study%20jm%2007.07.pdf)
- **Marasteanu**, Mihai, University of Minnesota, Department of Civil Engineering, (July 11, 2007) Power Point presentation at the *Hassan / Omann Project* luncheon meeting.  
[http://shinglerecycling.org/images/stories/shingle\\_PDF/hennepin-07.07-shingles%20mm.pdf](http://shinglerecycling.org/images/stories/shingle_PDF/hennepin-07.07-shingles%20mm.pdf)

The *Dakota County / MOEA Lab Analyses Project* was funded by the Minnesota Office of Environmental Assistance (MOEA). This project directly complemented a parallel study sponsored by the Missouri Department of Transportation (MoDOT). (See MoDOT project description below.) The pavement test sections were constructed in the fall of 2005 with tear-off RAS used in the base course only (i.e., no shingles were used in the surface wearing course). The tear-off pavement test sections show no observable difference compared to the control pavement sections with manufacturers' RAS and no shingles (RAP only). Lab results were reported by Mihai Marasteanu (July 12, 2006) and Jim McGraw (July 12, 2006). In summary, the impacts on mix design due to addition of tear-offs RAS showed little to no significant difference compared to the manufacturers' RAS. The principal concern was the potential for negative impact of tear-off RAS on the low temperature cracking as reported by Marasteanu.

The following links offer further details on the *Dakota County / MOEA Lab Analyses Project*:

- **Krivit**, Dan, "[Shingles Recycling: Co-Sponsors Who's Who](#)", Meeting/Workshop, July 12, 2006.
- **Marasteanu**, Mihai; Zofka, Adam, "[Summary of Shingle Work at the University of Minnesota](#)", University of Minnesota, Civil Engineering Department, July 12, 2006.
- **McGraw**, Jim, "[Mn/DOT Shingle Study](#)", Minnesota Department of Transportation, Materials Research Lab, July 12, 2006.
- **Schroer**, P.E. Joe, "[Asphalt Shingles in HMA Missouri DOT Experience](#)", Missouri Department of Transportation, Construction and Materials Division, March 30, 2005.

#### Missouri

The Missouri Department of Transportation (MoDOT) adopted an HMA materials specification that allows both manufacturers' shingle scrap and tear-off shingle scrap. The [MoDOT specification](#) was issued in 2005 and was the result of field pavement testing and lab research. Results indicate a very durable, more-rut resistant asphalt at a lower cost. Research and development has continued since that time with three contractors in Missouri submitting mix designs for regular paving projects as per the requirements of the state DOT specification. The

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standard virgin binder performance grade (PG) for traditional HMA mixtures in Missouri is PG 64-22. The MoDOT specification was developed with the intent that at 5% tear-off RAS in the HMA mix, the mix design with shingles must be adjusted to incorporate a “softer” virgin binder. HMA with 5% shingles must use a virgin binder that is one grade softer from the traditional grade. This softer virgin binder of PG 58-28 must be used unless additional test results could support alternative mix design plans. Based on this specification and additional testing, MoDOT has allowed up to 2% RAS in PG 64-22 HMA without adjusting the virgin binder with a softer grade.

South Carolina

The South Carolina Department of Transportation co-sponsored a study in April 2001, *Field Evaluation of Use of Waste Shingles in Asphalt Mixtures*, by SN Amirkhanian and KM Vaughan from Clemson University. Approximately one mile of road section (two lanes) was paved using 8% tear-off RAS in the HMA surface course. Relatively few problems were encountered during the production and placement process. Subsequent testing of the in-place cores indicated that all test properties were satisfactory. Rideability (smoothness) results, although within specifications, were somewhat worse for the mix containing shingles than for surrounding control sections. Follow-up research steps were recommended and one is underway.

The 2001 Amirkhanian study lead to a SCDOT specification allowing manufacturers’ or tear-off RAS into HMA in the range of 3% to 8%. Ashmore Brothers, Inc. is the primary contractor that regularly uses tear-off RAS in their HMA mixes mostly at 3%. SCDOT uses a total combined HMA mix viscosity test to determine job mix design. Ashmore is currently using a maximum of 3% tear-off RAS and zero RAP as their best means to attain SCDOT mix design standards. SCDOT approves Ashmore's mix designs and they are very pleased with the tear-off RAS HMA mixes and pavements. Ashmore uses the tear-off RAS in two of their three HMA plants in SC, and is working on introducing it into their third plant. The Ashmore HMA quality control manager reports that the tear-off RAS-derived HMA works out well with great compaction and tensile strength retained (TSR) lab results compared to traditional mixes without RAS. Ashmore has been using the tear-off RAS in the base and binder (middle) courses, but is currently working to get SCDOT approval for using it in surface course of HMA.

Conclusion

State specifications and BUDs for using RAS in paving projects are based on DOT–sponsored and other laboratory analyses. The entire body of research indicates that the benefits of using manufacturer's RAS in traditional HMA may include:

- Potential to enhance densification.
- Felt-backed RAS does not negatively influence moisture sensitivity at low percentage blends (5% or less of RAS in the mix).
- The grade of asphalt cement used in shingles is, in general, much harder than standard grades of asphalt used in traditional HMA pavement mixes. This difference in asphalt grade has advantages (e.g., potential for reduced rutting) and disadvantages (e.g., potential for increased low temperature cracking).

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- Permanent deformation (i.e., rutting) characteristics can be improved when blended in to HMA using a softer virgin asphalt binder.
- Potential to reduce costs of virgin asphalt binder by partial replacement with the RAS binder. In general, felt-backed shingles will have more asphalt cement content than fiberglass-backed shingles.

Laboratory analyses indicate that the disadvantages of using manufacturer's RAS in traditional HMA may include:

- Fiberglass-backed RAS may increase moisture sensitivity especially at higher levels of RAS (10% or greater), but there is little impact on resilient modulus.
- Cold tensile strength is reduced (leading to an increased potential for cold temperature or fatigue cracking) depending on type of shingles (felt vs. fiberglass, manufacturer's vs. tear-off).

The research and materials specifications for recycling of shingle scrap into HMA are built upon the successful development of the RAP technology. Some state DOT specifications allow a maximum of 20 to 30 percent RAP depending on the type of mix and pavement traffic conditions. According to the Mn/DOT bituminous HMA specifications, RAS is considered a type of RAP for purposes of calculating the maximum amount of recycled product.

The technical engineering and economic feasibility of recycling shingle scrap is dependent on adequate material QA/QC procedures. These QA/QC procedures are needed throughout the entire recycling operation in each component of the system. It is imperative that a high quality RAS product be reliably produced from the shingle recycling operation. Also, the supply of scrap feedstock should come from known, certified sources.

There is general consensus that the relative amount of manufacturers' RAS in HMA should remain at a 5 percent maximum by weight of aggregate using standard mix design and virgin asphalt binders. This standard 5 percent level provides an optimum balance between maximizing the benefits of adding RAS while minimizing any potential negative impacts on pavement performance.

The industry is moving towards calibrating more precisely the optimum amount of RAS to be included in a mix using more sophisticated lab analyses and engineered mix designs. This may include corresponding adjustments to the virgin asphalt binder performance grade (PG).

The primary economic driver in this technology is the proven, significant cost savings in partial replacement of virgin asphalt binder. The value of shingles recycling will increase proportionally to the price increases of virgin asphalt cement. Secondary economic drivers may include: avoided cost of landfill tipping fees; partial replacement of virgin aggregates; and the added fiber content.

### **Testing for Effects on HMA Pavement Performance and Mix Design**

In general, the HMA that contains RAS should meet or exceed the normal state QA/QC requirements for traditional HMA. Many state DOTs require the following tests as part of normal



QA/QC procedures for HMA specifications: tensile strength retained (TSR); air voids of the HMA mix (as sampled behind the paver before compaction); in place density (after compaction); and final inspection after pavement installation of cracking and other visual observations.

Methods of sampling and testing should be planned as part of any shingles recycling research project. Researchers should plan to sample at each step in the shingle recycling / HMA process including RAS pile, RAP pile, loose HMA behind the paver, and final cores after compaction.

The following parameters have been studied by a variety of shingles recycling research projects and should each be carefully considered when planning for additional research: asphalt cement (AC) content in the RAS, RAP and final HMA mix; performance grade (PG) of the final HMA mix; gradation of RAS; gradation of the final HMA mix; mix ratio of RAS; and deleterious substances.

Several additional shingles recycling research questions have been studied to further examine the impacts of RAS on the HMA pavement and mix design. These additional research parameters and tests have included: binder extraction; asphalt cement performance grade (PG); bending beam rheometer (BBR); and indirect tensile strength (IDT) tests. These are not traditional tests and, in general, are not normally required as part of state DOT regular QA/QC procedures. Academic institutions with more advanced laboratory research procedures have partnered with state DOTs and other project operators to conduct these additional tests.

### **Health and Safety of Employees at the Shingle Recycling Plant**

Shingle recyclers must strive to maximize the protection of the health and safety of their workers at all stages including system planning, design, construction, ongoing operations, and marketing. It is important to note that these workplace risks will be negligible if best practices are implemented and the overall recycling system QA/QC plan and implementation is thorough.

The employee hazard prevention plan should include best available information about asbestos and other dust management and exposure prevention similar to the types of information provided on the [ShingleRecycling.org](http://ShingleRecycling.org) Web site. Shingle plant operators that are fully informed and trained will be the company's most important strategy to safely produce a high quality product free of any asbestos risks. Employees will be the first line of quality assurance from every step such as feedstock quality control (e.g., rejecting unacceptable loads), through dust management during grinding (e.g., maintaining optimum grinding conditions), to RAS product sampling.

### **Road Safety**

The state DOTs that have studied asphalt shingle use in paving projects have not identified road safety performance as an issue. However, the importance of the recycled asphalt shingles (RAS) to be free of contaminants, such as nails, is critical for both worker safety and road safety.

### **Environmental Impacts**

Shingle recycling systems should be planned, designed and implemented to fully comply with or exceed all waste disposal regulations. Asbestos management plans must be developed in

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accordance with federal NESHAP asbestos regulations as promulgated by the U.S. EPA. NESHAP is administered and enforced by the state environmental agency.

The vast majority of tests conducted on asphalt shingles have found no asbestos. But some types of other asphalt roofing products, such as roll roofing, adhesives, paints or waterproofing compounds may contain asbestos. Several states have worked with recyclers to conduct initial testing on their waste stream to demonstrate the safety of their operation.

Results of past asbestos sampling studies were summarized as part of the ongoing “Asphalt Roofing Shingle Recycling Assessment Project” (ARSRAP). Dr. Timothy Townsend, et. al. (Innovative Waste Consulting Services, LLC) recently updated the summary and analysis of this ARSRAP data in a separate document entitled “Environmental Issues Associated with Asphalt Shingle Recycling”.

The [ShingleRecycling.org](http://ShingleRecycling.org) Web page is a key portal to a significant amount of EPA and other regulatory information about asbestos regulation, management and other recommended best practices. It is up to the recycler to determine the specific state and local regulations that may apply.

### **Ongoing Information Dissemination**

A number of next steps are anticipated to continue the dissemination of research and other technical assistance resources.

- LinkUp Shingles in Paving Demonstration *Project Stakeholders* and other interested parties can check the Project Web page regularly for new information about the project. The project team will notify Stakeholders when the links to the documents mentioned in this memo are included on this Web site.
- *Project Stakeholders* can browse an extensive list of literature resources on asphalt shingle recycling, including technical reports, articles, fact sheets, and presentations, with document links where possible, at [http://shinglerecycling.org/index.php?option=com\\_content&task=view&id=52&Itemid=76](http://shinglerecycling.org/index.php?option=com_content&task=view&id=52&Itemid=76).
- *Project Stakeholders* and other interested parties should consider attending the 3<sup>rd</sup> *Asphalt Shingle Recycling Forum* in Chicago on November 1 – 2, 2007. LinkUp may consider financial assistance for selected representatives of the LinkUp Shingles Project Advisory Group to attend. For more information, link to Construction Materials Recycling Association’s 3<sup>rd</sup> *Asphalt Shingle Recycling Forum* Web page: [http://www.shinglerecycling.org/index.php?option=com\\_content&task=view&id=186&Itemid=277](http://www.shinglerecycling.org/index.php?option=com_content&task=view&id=186&Itemid=277)
- The LinkUp Asphalt Shingle Project Team will soon be organizing the first meeting of the project advisory group. Meeting summaries will be posted on the Shingles in Paving Demonstration Project Web site.

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**Table 2. Key Findings of Select Shingle Recycling Projects**

Project Title	Type of Project	Primary Sponsor	Secondary Sponsor	Dates	Type of RAS	Contacts	Current Status	Key Findings
Ramsey County Lower Afton Trail (LAT)	Pedestrian / Bike Trail	Ramsey County, MN	Mn/DOT	2007	T	Bob Paine, Ramsey County Dept. of Public Works	<p>Project specifications written and released. Bids received from multiple contractors.</p> <p>Contract awarded to Rachel Construction (primary). Rachel subcontracted with Midwest Asphalt for paving / HMA production.</p> <p>Shingles "grinding" scheduled for early October 2007.</p>	<i>Study is in beginning stages. No findings at this time.</i>
Hassan / Omann	Rural township road. Formerly aggregate surface, paved with HMA test strips.	SWMCB, Hennepin County, Mn/DOT	U of MN Dept. of Civil Engineering, Town of Hassan, Omann Brothers Inc., Dakota County, LRRB, DKA	2006-2007	M, T	Dan Krivit and Associates. Mn/DOT. U of MN. Hennepin County.	<p>Multiple funding sources secured, paid in early to mid 2006.</p> <p>Final project meeting held on July 11, 2007.</p>	<p>U of MN testing: Inconclusive results on HMA low temperature and fatigue cracking impacts as measured in the lab using the indirect tensile (IDT) strength test; 10% tear-off RAS result in greater creep stiffness compared to the same mix using manufacturers' RAS.</p> <p>Mn/DOT lab results: The percent AC and PG grade in the final HMA core samples varied by mix type and amount of RAS used in the mix; the relative impacts of tear-off vs. manufacturers' RAS on the PG grade were about the same at the 5% RAS level. The impacts of tear-</p>

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Project Title	Type of Project	Primary Sponsor	Secondary Sponsor	Dates	Type of RAS	Contacts	Current Status	Key Findings
								off RAS on the PG grade at the 10% RAS level was about 2½ grades at the high temperature and ½ grade at the low temperature. Adjusting the virgin asphalt binder to the softer PG 52-34 decreased both the high temperature and low temperature by ½ grade. The resulting final mix, with the adjusted, softer virgin binder, was close to original, targeted mix design PG 58-28. Many more parameters tested.
Dakota County MOEA Lab Study	County Road / State Aid Highway arterial.	MOEA (now MPCA); Dakota County	Mn/DOT; U of MN Dept. of Civil Engineering, Bituminous Roadways Inc.	2004-2006	M, T	Dan Krivit and Associates. Mn/DOT. U of MN. Dakota County.	MOEA funding secured in 2004. Project paved in 2005. Lab work in 2005 - 2006.  Final project meeting held on July 12, 2006.	U of MN testing showing potential for tear-off RAS to cause increased low-temperature cracking on HMA.  Mn/DOT lab results: Consistent AC content within tear-off RAS averaged about 30%.
MoDOT Lab Study	More than one type.	MoDOT	Pace Construction Inc.	2004-2006	M, T	Joe Schroer	Mo/DOT and Pace Construction collaborated with Mn/DOT and U of MN to conduct IDT tests in 2005.	Mo/DOT's specification for use of tear-off shingles in HMA at up to 5% with adjusted virgin binder PG grade verified by U of MN strength and creep tests using IDT.

**Key to type of shingle scrap used:**

*M: Manufacturers' shingle scrap was used*

*T: Tear-off shingle scrap was used*

**King County LinkUp: Shingles in Paving Demonstration Project**  
**Memo of Recent Research on Shingles Recycling**

Project Title	Type of Project	Primary Sponsor	Secondary Sponsor	Dates	Type of RAS	Contacts	Current Status	Key Findings
MoDOT Mix Design Approval	More than one type.	MoDOT	Jornagen Construction Inc. and two additional contractors	2005 – 2007 (ongoing)	M, T	Joe Schroer	Mo/DOT has worked with two additional contractors in 2007 to approve mix designs per Mo/DOT spec.  Contractors are using 2% RAS of tear-off shingles to avoid added costs of adjusting AC virgin binder.	<i>Study is in beginning stages. No findings at this time.</i>
SCDOT mix design approval	HMA in road construction: base and binder courses	SCDOT	Ashmore Brothers, Inc.	2005 – 2007 (ongoing)	T	Cliff Selkinghaus, SCDOT Stewart Boone, Ashmore	Ashmore is the primary contractor that regularly uses tear-off RAS in their HMA mixes mostly at 3%.	SCDOT uses a total combined HMA mix viscosity test to determine job mix design. Ashmore is currently using a maximum of 3% tear-off RAS and zero RAP as their best means to attain SCDOT mix design standards. SCDOT approves Ashmore's mix designs and they are very pleased with the tear-off RAS HMA mixes and pavements.  Ashmore uses the tear-off RAS in two of their three SC HMA plants. Working on introducing it into their third plant. Tear-off RAS- derived HMA works out well. Compaction is great. Often better TSR results compared to traditional mixes without RAS. Working to get SCDOT approval for use of tear-off RAS in surface course of HMA.

**Key to type of shingle scrap used:**

M: Manufacturers' shingle scrap was used

T: Tear-off shingle scrap was used